Panel: Graduate Student and Postdoctoral Fellow Perspectives on Advancing Women and Gender Equity in Engineering - for the Next 130 Years

Dr. Baishakhi Bose, Lawrence Berkeley National Laboratory

Baishakhi Bose is currently a Postdoctoral Scholar at Lawrence Berkeley National Lab (LBNL). Her current research focus is on life cycle assessment of novel polymers, building materials and plastic recycling processes. She obtained her PhD. in Materials Engineering from Purdue University in 2021. Since 2014, she has taught courses in Civil, Materials and First Year Engineering to undergraduates, and mentored undergraduate and graduate students in STEM to foster research and professional development skills. She also has relevant experiences in organizing undergraduate research symposium/conferences, hosting professional development workshops, providing guidance on undergraduate/graduate school application. Currently, she serves as a Teaching Scholar for the K-12 STEM Education Program at Berkeley Lab and is involved with curriculum development of K-12 outreach at LBNL.

Haleh Barmaki Brotherton, Clemson University

Haleh Barmaki Brotherton is a graduate student in the Department of Engineering and Science Education at Clemson University. Her research interests include perfectionism, self-regulation, and decision-making. She earned her BS and MS from Middle East Tech

Theo Hopper, University of Michigan

Theo Hopper is currently pursuing their PhD in biomedical engineering at the University of Michigan, Ann Arbor, Michigan, United States. They received a B.S. in bioengineering from Endicott College, Beverly, Massachusetts, United States.

Pamela Martínez Oquendo, University of Nebraska-Lincoln

Pamela Martínez Oquendo is a cis-gender, heterosexual female, and a Ph.D. candidate, focusing on Discipline-Based Education Research at the University and Nebraska-Lincoln. Her long-term goal is to disseminate science education knowledge by conducting outreach programs with the community to build bridges between research and education in the STEM fields. Her aim is to motivate and increase the number of students interested in pursuing schooling and careers in STEM-related areas. Pamela completed her Bachelor of Science at the Pontifical Catholic University of Puerto Rico.

Dr. Lily M. Wang P.E., University of Nebraska-Lincoln

Dr. Lily Wang is the Charles W. and Margre H. Durham Distinguished Professor of Engineering and Technology, and Director of the Durham School of Architectural Engineering and Construction in the College of Engineering at the University of Nebraska - Lincoln. Her primary research interests are in room acoustics and noise control, particularly human perception and performance in noise, classroom acoustics, uncertainty in acoustic measurements, and room acoustics computer modeling. Dr. Wang is a Fellow of the Acoustical Society of America (ASA); Board-Certified by the Institute of Noise Control Engineering; a Professional Engineer licensed in Acoustics through the state of Oregon; and a recipient of the ASA Hunt Postdoctoral Fellowship, ASA R. Bruce Lindsay Award, NSF CAREER Award, and ASHRAE Ralph G. Nevins Physiology and Human Environment Award. She has also received a number of teaching and mentoring awards, including the ASA Student Council Mentoring Award.

Margaret E.B. Webb, Virginia Tech

Margaret (Maggie) Webb is a master's and Ph.D. student in sustainable land development (civil engineering) and engineering education, respectively, at Virginia Tech. She graduated with her mechanical engineering degree from Rice University and worked for ExxonMobil as a subsea engineer and as a high school STEM teacher in a Houston charter school before starting grad school. Her research interests include supporting the needs of displaced engineering students, understanding the supports and barriers to

educational continuity for engineers in a disaster context, and preparing engineering students interdisciplinarity to address disasters in their work. She works as a graduate research assistant for the Virginia Tech Disaster Resilience and Risk Management interdisciplinary graduate program, as well as for the VT Center for Refugee, Migrant, and Displacement Studies.

Hannah Wilkinson, Utah State University

Hannah Wilkinson is a graduate student in Engineering Education at Utah State University. She received a B.S. in Chemical Engineering in from the University of Utah.

A Panel Envisioning Gender Equity in Engineering for the Next 130 Years: Perspectives from Graduate Students and Postdoctoral Researchers in WIED

Abstract

In celebration of 130 years of the American Society of Engineering Education (ASEE), the Women in Engineering Division (WIED) at ASEE convened a panel of current graduate students and postdoctoral scholars to discuss visions of gender equity in engineering 130 years from now, where all gender identities feel respected, experience gender equity, and are able to maintain a healthy work-life balance. The panelists reflected on their experiences on advancing womxn and gender equity in engineering, envisioned the progress that should be made in the coming 130 years, and shared ideas on how to achieve those visions, focusing on how dualistic thinking around gender and cis-normativity serve to marginalize womxn in engineering's learning environments and workplaces, as well as the critical ways that racial identity and gender intersect in womxn of colors' experiences. Presenters shared ways they are enacting structural changes and social justice initiatives to propel towards a more equitable future for all womxn in engineering. These reflections provide a perspective that is not commonly found in the current literature, and their conclusions provide insight into where future research efforts could be focused.

Introduction

The United States Congress has made many efforts to increase the number of womxn and underrepresented minorities in Science, Technology, Engineering, and Mathematics (STEM) [1-2]. In this panel paper, the word "womxn" is referencing the intersectional feminist spelling of the word "woman"; this spelling seeks to avoid the suggestion of sexism and dualisms of gender and sexuality, to be inclusive to trans women and nonbinary people, and to demonstrate demanded equal treatment for womxn [3]. Womxn are encouraged to pursue schooling and careers in STEM [4], but less than 45% of STEM college students' population consist of womxn and minorities [5] and academic definitions of womxnhood in engineering are often limited to dominant (i.e. cis-gender, heterosexual, and white) perspectives, marginalizing the perspectives of diverse womxn in the field and creating systemic barriers to their equitable participation in STEM [6-12].

Recognizing that diversity is key to supporting engineering and innovation [4], institutions of higher education have made extant efforts to encourage the enrollment of womxn and minorities in STEM, but often, once enrolled, colleges and universities make minor efforts to ensure that womxn complete their degrees [13]. Engineering as a field in general lacks a clear vision for intersectional gender equity, and disaggregated perspectives of womxn in engineering are lacking. In addition, while we know that retention is key for supporting diverse participation in STEM and that issues for womxn in engineering do not stop in the undergraduate classroom, research in womxn's experiences of equity in engineering are lacking at the graduate and postdoctoral level, neglecting the perspectives of the future womxn professoriate. In order to fill the gaps between undergraduate womxn's experiences and womxn in the workforces' perspectives, this work brings forward the narratives of current womxn graduate students and postdoctoral researchers in STEM and motivates future research in womxn engineering faculties' experiences of gender equity and the role the dominant cultures of engineering play in increasing the participation of diverse and marginalized womxn in STEM.

Background

As discussed, the perspectives of current graduate students and postdoctoral researchers are not often brought forward at conferences and in the literature. So in spring 2022, the ASEE Women in Engineering Division (WIED) sent out a call for applications for graduate students and postdoctoral researchers who would be willing to participate on a panel at an upcoming ASEE meeting to discuss their perspectives of the future of womxn in engineering, coordinated by WIED Director-at-Large Dr. Lily Wang. Over 30 applications were received; from those, twelve were selected, with six of them grouped to present in 2022 at the ASEE annual conference in Minneapolis and six grouped to present in 2023 at the ASEE conference in Baltimore. For this paper, the six panelists are those selected for a panel discussion at the ASEE conference in Baltimore, and the panelists are: Dr. Baishakhi Bose (Lawrence Berkeley National Laboratory), Haleh Brotherton (Clemson University), Theo Hopper (University of Michigan), Pamela Martínez Oquendo (University of Nebraska - Lincoln), Margaret Webb (Virginia Tech), and Hannah Wilkinson (Utah State University). In preparation for the panel, the group met periodically beginning in fall 2022 to discuss their perspectives on advancing womxn and gender equity in engineering for the next 130 years and compiled a list of questions to address individually. This article contains the collected reflections of the six panelists; all panelists contributed equally to the compilation of this manuscript, with authors listed alphabetically by last name, and each panelists' expressed views are their own, and are not reflective of other panelists' opinions and/or the views of their workplace/institution.

For brevity, the panelists are referred to as R1, R2, R3, R4, R5 and R6, corresponding to the following:

- R1: Baishakhi Bose is a woman of color and an international student in the USA. Her experiences are based on living in several countries and pursuing specific engineering fields in which women are a minority. She is currently a postdoctoral fellow at Lawrence Berkeley National Laboratory and completed her PhD at Purdue University.
- R2: Haleh Brotherton is an Iranian PhD student in Clemson University. Her academic journey has taken her from living in Europe to Canada and finally to the US. This journey has led her to achieve two master's degrees in industrial design and industrial engineering. Embracing every step of her academic journey in various parts of the world has helped her to find her research passion in women engineers and perfectionistic tendency.
- R3: Theo Hopper is a white, non-binary, queer graduate student at the University of Michigan from the US.
- R4: Pamela Martínez Oquendo is a Hispanic, cis-gender, and heterosexual graduate student at the University of Nebraska – Lincoln in the US.
- R5: Margaret Webb is a white, cis-gender, and queer graduate student at Virginia Tech from the US.
- R6: Hannah Wilkinson is a white, cis-gender, neurodivergent graduate student at Utah State University from the US.

In preparation for the panel, six questions were posed to the panelists. This article contains the collected reflections. The six questions were:

1. What are your goals for gender equity in engineering for the next 130 years?
2. What are you doing to reach your goals for gender equity in engineering?
3. How do you deal with being 'one of the only' <identities> in engineering spaces?
4. How do you resolve tensions between respecting peoples' cultures and religions and staying true to your values of gender equity?
5. Reflect about how recent events in the world are *influencing* the future of womxn in engineering.
6. What examples of structural change are important for realizing your goals for gender equity in the next 130 years?

Results

1. What are your goals for gender equity in engineering for the next 130 years?
Panelists discuss their visions of a future 130 years from now, where engineers of all gender identities feel respected, experience gender equity, and are able to maintain a healthy work-life balance.

R5: In my opinion, a critical first step towards gender equity in engineering education and the workplaces thereafter is expanding the fields' cultural and dualistic ways of thinking around gender. This is a large task, but it includes educating engineers about dualistic social constructions of gender and sexuality and the ways in which the macroethics of the field intersect with gender equity. This means that until it is common to recognize and include the broader spectrum of gender into engineering spaces and conversations, we are still missing the mark on gender equity by a long shot.

Aligned with findings from scholars [14], I see the engineering field still holding tight to a social-technical divide, or the assumption that the more technical aspects of engineering should and are better off being separate from more social or emotional ones– that the social aspect takes away from the technical. The cascading and systemic effects of these ideological or cultural belief systems based on dualisms play important roles in reproducing gender inequity where the divides become man versus womxn or heterosexual versus homosexual as opposed to more expansive definitions of humanity. From my previous work experience, it seems like this happens because engineering institutions make assumptions about engineers based on culture and bias across generations, and they use those assumptions to make policy and procedure decisions that affect all the engineers in those institutions, often inequitably. In assuming all engineers are a certain way and that the ideal engineer is someone who holds true to the social/technical divide and is an able-bodied, cis-gender, and heterosexual man, workplace norms and incentive structures are designed with these people in mind, systematically disenfranchising queer engineers.

Later steps in addressing equity in this space would include engendering gender equity into engineering culture and ways of doing and considering the ways in which engineering culture's assumptions about gender are structurally embedded in our education systems and workforce– not only recognizing the importance of diversity in the field but also ensuring the important differentiation of support structures so that engineering can become a more level playing field. In other words, in order for all engineers to feel respected, experience gender equity, maintain a

healthy work-life balance, those maintaining the structures associated with the field need to reevaluate the way they define gender and its place in engineering in systemic ways.

R3: My goals for gender equity in engineering are centered around the experiences of women, nonbinary, and trans-people, who often need to work harder to define their identities and engineering skills. Many of these individuals also experience a sense of imposter syndrome, and believe that they do not belong in engineering and did not earn their achievements. In the future, I hope that individuals' viewed competence is not dependent on their perceived gender. Furthermore, I hope that we move from a place of assuming the gender of individuals in engineering, which enforces the gender binary, and allow people to express and identify as any gender they see fit. In engineering, many people still believe in and promote bioessentialism [15]- the idea that there are two genders based on biology, although as a biomedical engineer, I have come to realize that nothing in biology is actually binary - which is used to oppress people who want to explore other gender identities.

R2: I believe (and want to believe) that in 130 years, gender equity in engineering will gain a new definition in terms of a healthy work environment, performance and feeling accepted. I think today's research and activism toward gender equity represent an important step to achieve this goal. 130 years from now, envisioning the end goal plays a key role here in defining my goals. With the end goal in mind, one of my objectives is to ensure my mentees and colleagues feel seen and heard by different means. For example, I have a pin in my office that says, "*Tell me your pronouns*!" with a note that states "*Affirming a person's pronouns lowers depression and raises self-esteem. By using a person's pronouns correctly you show them respect*." While such acts may not solve the gender equity challenges directly, it would provide a sense of belongingness and transfer the feeling of "I see you!" which is very important towards achieving a future where gender equity is a reality.

R6: An important aspect of gender equity is valuing the work womxn do as much as the work done by men. In the U.S. in particular, there has been a pattern of work being undervalued if it is traditionally done by womxn or decreasing in value if a field begins to shift away from being male-dominated [16]. We can see this in the stereotype for example in industrial engineering, which has a large percentage of womxn and other gender minorities compared to other kinds of engineering, is considered as "easy" or "not real engineering" despite evidence that it is equally as rigorous as other types of engineering [17]. 130 years from now, I see engineering being more focused on how problems are solved than what kinds of problems are solved, and also not focused on the gender identity of the engineer. As engineering, technology, and social issues become increasingly intertwined, I see gender equity as an avenue for engineering to continue to be successful means of achieving greatness in technological advances but also creating social justice awareness.

R1: My goals for gender equity in engineering are centered around ensuring a future where the work-life balance of womxn in engineering is respected. I have seen many women in my family and professional network holding off on advancing their career or quitting their job/study as they became a caregiver. While every situation is different, I believe having a supportive and inclusive workplace can foster the growth of womxn who juggle multiple responsibilities in personal life, and I am hopeful of a future where no womxn is faced with the task of choosing between family responsibilities and career growth. 130 years from now, I hope womxn (and people of all gender

identities) feel comfortable enough to draw boundaries that respect both their personal and professional life balances. When I was a graduate student, my PhD advisor used to send emails that clearly depicted her intentions that she did not expect me to work outside of my regular work hours and the emails did not need immediate response, if it fell outside of my working hours. She would also encourage me to take vacations, explore hobbies unrelated to my research etc. This experience really taught me that I did not need to work well outside regular working hours to be perceived as a productive graduate student. Taking inspiration from my PhD advisor, I aim to be a mentor who respects her colleagues and mentees work-life balance too, so that I can contribute in a small way to a future where more womxn who have had gaps in their career or are juggling multiple responsibilities do not find work-life balance as a barrier for them to succeed/re-join/remain in the workforce. On a similar note, I envision a future where provisions are made in policy at institutions and workplaces so that all genders can avail adequate parental/bonding leave.

Additionally, for gender equity to be a reality in all fields of engineering, we need to think about the current and future pipeline feeding into the engineering students' pool. As such, another goal of mine is to ensure those from high schools identifying as gender minorities are offered the same resources and encouragement as their male peers to join certain fields of engineering where womxn are underrepresented. Keeping this goal in mind, I have been volunteering for K-12 education based initiatives, at each of the institutions I have been a part of. I have been involved in planning and volunteering for initiatives such as *Introduce a Girl to Engineering* [18] and *Science Accelerating Girls' Engagement in STEM* [19] which are directed towards high school girls.

Finally, I also would like to see a future where all marginalized communities (including womxn) are seen, celebrated and valued in the engineering workplace. This is possible through the work of not just womxn who have experienced past struggles, but also male allies, who are equally important in creating an inclusive environment where womxn's careers can flourish as much as their male counterparts.

R4: I ground my goals for gender equity in engineering for the next 130 years in my undergraduate and graduate mentorship experiences with faculty members as a Latina woman in STEM. As a college student, I found support and encouragement to attend graduate school from male and female faculty mentors alike. I did not perceive any type of discrimination from the faculty, regardless of gender. It is well-established in the literature that female faculty in STEM support women more than their male faculty [13]. Still, I must confess my most salient mentorship experiences and support came from male faculty. I found additional support from male faculty who had at least one daughter. Male faculty with daughters were more understanding of the struggles women undergo in society and STEM. Male faculty with daughters were more dedicated toward encouraging females to pursue advanced schooling. I believe these behaviors took place because male faculty saw the reflection of their daughters' struggles in their female students. It seems the future of gender equity in engineering may rely on mentors/supervisors who can internalize the struggles of students through lenses other than their own, and lies on male allies who support and foster women's achievement as much as women support each other.

2. What are you doing to reach your goals for gender equity in engineering?
Here panelists reflect on their experiences on advancing womxn and gender equity in engineering and share ideas on how to achieve their visions; these discussions include panelists' reflections of their other social identities that intersect with their gender identities in engineering.

R3: As a non-binary, masc-leaning person in the field of engineering, I am working towards promoting gender equity by living authentically and educating others about trans issues. I am involved in several initiatives to increase visibility and representation of LGBTQIA+ individuals in STEM, including running an Instagram page that highlights their achievements [20] (Hopper et al., 2022) and participating in the Letters to a Pre-Scientist program. I also prioritize creating a supportive and inclusive environment for all students in my role as a teaching assistant, by incorporating issues of gender equity into my teachings, respecting students' preferred names and pronouns, and improving the classroom climate. My goal is to promote a more just and inclusive culture in engineering by providing support and representation to marginalized communities and encouraging others to do the same.

R1: My identity as a woman of color in STEM, and hailing from a structural engineering background where a few womxn are seen in field work has given me a unique opportunity to appreciate the intersectionality of marginalization. I realized that by uplifting one marginalized community, I am creating a support group for all marginalized communities. I am acting on my goals by educating myself regarding the perils of different marginalized communities by participating in workshops, seminars and learning how I as a woman of color in engineering can actively support not just causes I personally relate with, but also those that affect my peers. For instance, although it is a very small step, being safe zone trained and having my pronouns next to my name when I introduce myself is one example of an inclusive practice I have adopted towards achieving a future where all genders are respected. I am also currently the spotlight team lead for the ASEE Commission on Diversity, Equity and Inclusion (CDEI), and in this role, I get to highlight various scholars and initiatives that are actively working on creating diversity and equity in institutions.

Additionally, I am working on achieving my goals of a future in engineering where there is gender equity in all fields by actively being in leadership positions in organizations that host events for K-12 programs. I have contributed to various K-12 initiatives through content creation, hands-on activities and supporting events that encourage young girls to learn more about a career in STEM. During my graduate studies at Purdue University, I used to volunteer for events directed towards K-12 students, through the Women in Engineering program. It was extremely fascinating to see elementary and middle school girls being excited by hands-on engineering activities that we would conduct in summer camps, and see how creative they can be at solving the problem at hand. I realized it is important to spark young girls' interest in engineering early on in their education, so as to hire and retain them in certain fields of engineering which are not considered as traditional pathways for womxn. At Berkeley Lab, I am part of the Teaching Scholar program where I volunteer for the K-12 outreach initiatives, and through this program I am able to contribute towards content development to be used for programs such as Science Accelerating Girls' Engagement [19], which is a program connecting marginalized gender students with STEM professionals. I have also mentored several high school girls and undergraduate women during my graduate school and postdoc tenure. During these opportunities, I like to learn about my

mentees' career goals and interests and help them in attaining resources to achieve their career objectives. I serve as executive committee member of women affinity groups both at my current workplace and in global organizations such as SWE, and through my service, my goal is to empower young womxn with resources that would help them visualize what a career in engineering would look like and choose to pursue it regardless of their social, economic or accessibility-based barriers. I believe through these small contributions, I can contribute towards a future where gender equity is a reality.

R6: Working in math education for 3 years part time during my undergraduate education and 2 years full time before graduate school, I've had the opportunity to work with children and youth from many different backgrounds and gender identities. I have helped students work against the pressures they sometimes feel from current gender-norms to be successful in math and pursue education in STEM if they are interested in it. As an undergraduate and graduate student I have done STEM outreach activities for elementary schools, girl scout groups, and high schools to encourage students to participate in engineering. I believe that K-12 outreach and mentorship is important to breaking down gender barriers and increasing participation of womxn in engineering.

R5: In graduate school I am trying to learn as much about the culture of engineering and its history of disenfranchising people based on gender and other social identities. I situate myself as a critical researcher and use my work to create more discussions and structural change around equity in engineering. In some ways as a grad student I see myself more as preparing for a career that will be aimed at goals of gender equity as opposed to actioning my goals; I think that grad students do not always have a lot of power to affect change or to educate large numbers of people in important issues, but when you start getting jobs in academia, especially when you have tenure, so have more room to shake things up. Right now I think of my job as trying to equip myself with as much knowledge and support from others so that when I do have some more power I can act on my ideas more systematically. A big focus of my thinking lately is on what the "broader impacts" I want my research to have one day. I know it is a typical-NSF buzzword, but I do want my work to have the long-term and compounding effects that make large-scale change.

R4: I am reaching my goals for gender equity by encouraging male faculty members to view womxn's struggles in STEM from a different perspective. I am supporting womxn and individuals with other gender identities to identify faculty mentors that can serve as role models in STEM, since mentoring is key for retaining students in STEM [21]. I would prioritize the examination of mentorship in prospective faculty teaching statements to identify individuals who will support all students pursuing a degree in engineering.

My intersecting gender and ethnic identities as a Latina woman in STEM have provided me with a broader perspective on the struggles of womxn in STEM who identify as PEERs—persons excluded because of their ethnicity or race [22]. It is essential for gender equity to provide supportive environments and experiences to all genders seeking to thrive in engineering, starting with appropriate mentorship.

R2: I think that one of the characteristics of graduate school is to teach us to learn every day. As part of that, I have been learning about effective communication in engineering. This has been an interesting concept in engineering, as I have observed many of my colleagues attend such

workshops including myself. In order to have effective communication, I think building a rapport with students is very important not only for their school but also for their personal growth. I had several female Creative Inquiry (CI) mentees this semester for the first time which taught me how effective communication matters. Building trust with my mentees helped me to understand how trust between mentors and mentees can directly affect their performance in school.

3. How do you deal with being 'one of the only' <identities> in engineering spaces?
Panelists are sharing tactics and ideas for influencing structural change so that others have more inclusive experiences; in doing so, they discuss how they are personally affected.

R4: Structural change starts at the individual level by shifting perspectives on things we think we know best. I have found myself lost in STEM disciplines in the United States. I was born and raised in Puerto Rico but cannot relate to Puerto Ricans born and raised in the US. There are massive differences in the cultural exposure of people who "look like" have experienced that I have not. People in STEM disciplines make assumptions about my feelings and perspectives because they had engaged with individuals who "look like me". My experience of completing my biology undergraduate degree on my home island differs vastly from accomplishing the same degree in the US. I believe structural changes must start by acknowledging that everyone has experiences that inform how they think and feel. It is imperative to avoid making assumptions about individuals within the field to foster a more inclusive environment in STEM.

R1: It is important to realize that there is always intersectionality in marginalization. I have often seen that although I may be the only Bangladeshi woman with a structural engineering background in the room, other womxn of color (or even men of color) might identify with my struggles. I believe in such cases, solidarity is key. At times, it might be important to speak about one's struggles because it gives space for those who are in the same situation to realize that they are not alone. At other times, when one is not in a position to speak up (due to the stage of their career they are in or other situations that might just be uncomfortable) it might be easier to seek the help of a mentor who is an ally to intervene in the situation, or even just be a safe space for discussion. Nonetheless, I understand that there are always some womxn who have to navigate their experiences in STEM on their own, and I always strive to provide support to such womxn if I come across their path.

R3: As often the only open non-cisgender and queer person in academic spaces, I often feel the need to act as a model minority. I am often the only trans person whom people know personally, so it can feel like I need to act in certain ways to be a good representative for my community. This often leads to me not speaking out against microaggressions or injustices, so I am not seen as overly sensitive or too vocal about social justice issues. I am actively trying to shed this way of thinking and be more myself in these spaces.

R5: My tactic as an often lone woman in a room, office, or organization of engineers is to study the dynamics of the workplace. I use my observation skills to notice people's hidden expectations in the classroom or workplace, critique dysfunctional dynamics, and think about how these phenomena show up in structures embedded in the policies, practices, and procedures of engineering spaces. I take a critical approach to the way I understand the dominance of men and their ways of doing in engineering because of the pain and sense of othering I felt when I didn't

approach these spaces this way. I think it's this same critical lens that serves me best in research about gender equity and other inequity issues in engineering education; these problems are not just on an individual level, they are systemic.

R2: As an Iranian woman, I always feel the need to prove myself. Partly, this could be inspired by my mom, who is the only female electrical engineer in the entire engineering department in Iran. I attach this feeling to perfectionism as a response to avoid imposter syndrome. While it can be draining, I have learned how to cope with negative perfectionism and led it more toward positive perfectionism that could help me accomplish my goals.

4. ***How do you resolve tensions between respecting peoples' cultures and religions and staying true to your values of gender equity?***

R5: Personally I struggle with this because of the way religion has impacted my personal life over the years and the way I perceive its effects on people who experience womxmhood. I think what is important to remember in these sorts of conversations involving tensions between respecting culture and religion and staying true to my values of gender equity is that I have to separate religion on the whole from the individual people practicing the religion. I think most people mean well and want to do good in the world because of their religious values, but I also think it can be hard to see how religion in a larger sense marginalizes people we might care about on a personal level.

R6: For me it involves recognizing the diverse ways in which people experience womxnhood (even those whose religions and cultures are more male-dominated) as a benefit to society; religion should not step on the rights of others to simply exist, but it also should not be considered anti-womxn inherently.

R3: In conversations with people who do not agree with my opinions about equity, I think it is important to convey my point of view without saying anything against the person or their views. I hope to add perspective and education about issues, but acknowledge that it is unlikely they will not ever agree or concede on their point of view. Instead of trying to convince them that I am correct and they are wrong, the goal is to reach a point of mutual understanding and respect. Some people will never allow you to reach that point with them, and in this case, I would distance myself as much as possible. There is no point in trying to have a relationship with someone who does not respect my identities and viewpoints, and my emotional, physical, and mental safety is the most important thing.

R4: I resolve tensions between other people and myself by empathizing with the experiences of individuals, as well as their cultural and religious differences. Empathizing with the cultural tensions and pressures people face in their cultures and religions has allowed me to be more open-minded. I had to learn to avoid taking things personally. Every culture and religion has challenges and expectations. I have come to understand that I don't need to agree with the beliefs of others, but I must respect the feelings and attitudes of people toward those beliefs.

R1: Having had the opportunity to have lived in several countries and the chance to experience different cultures, I think it is important to educate people on cultural dexterity. As an engineer, we should not only focus on our technical skills growth, but also to develop ourselves

professionally, and be able to handle situations where we have to interact with someone with a different cultural/social/racial/religious background. The ability to respect someone else's practices and culture, while still staying true to one's own cultural identity is possible if both the parties are aware of and respect the differences. I believe through workshops and training sessions, this can definitely be achieved, as people become more aware of their implicit (and sometimes explicit) biases. This would especially be important if one serves as a mentor. Thus, it is important to provide training to those who would mentor others in any capacity so that they are aware of communication tactics to ensure an inclusive space for their mentees, despite the differences in their cultural/social or other backgrounds. The training on effective and inclusive mentoring I have completed during my graduate school and through Lean In.org have helped me in being more cognizant of biases and being a more inclusive mentor overall. Also, I have been inspired by how my graduate school and postdoc supervisors have created an inclusive workspace for me, despite the difference in cultural background, and in future I hope to emulate their communication and engagement tactics with my mentees.

R2: I believe that education is needed in this area to allow all parties to know the types of behaviors that would be accepted. For example, workshops and short courses could be designed to educate individuals on different cultures, backgrounds, and gender equity.

5. ***Reflect about how recent events in the world are influencing the future of womxn in engineering.***

R4: It is well known that women struggle to belong and thrive in STEM [23]. Often, women who receive a degree in STEM decide to pursue careers in healthcare and the educational sector, rather than deciding to continue in STEM [24]. Because of this, the few women who decide to stay in STEM may struggle with the pressures of showing persistence and representation of the female gender, especially when deciding to have a family. Findings from [25] showed that nearly 50% of women leave their full-time employment in STEM after having children. These statistics show that deciding to have a family impacts the retention rates of women in STEM.

This data made me reflect on the decision of one of my female classmates to abandon her Bachelor of Science to pursue a degree in education. She had changed majors because she had female family members with STEM jobs who had sacrificed time with their families to excel at their jobs. For example, one of her aunts would constantly be absent from her son's weekend soccer games because she was always working. As this female classmate reflected on her future as a mother, she opted to leave STEM instead of risking not having enough time for her children. Similarly, I had a female professor who publicly shared her experience of becoming a mother while pursuing her doctoral degree. This female professor decided to stay in the lab over the weekend and miss her son's baseball game. When she told her male research advisor about her decision, he convinced her to attend her son's baseball game even if it meant delaying lab work.

It seems that womxn in STEM feel pressured to stay at the same performance level as their male counterparts, both while completing their degrees and at the workplace. Womxn are constantly pressured to prove themselves repeatedly during their professional careers. Womxn can ultimately feel pressured to sacrifice spending time with their children or decide to not have a family for the

sake of their careers. It seems the expectations of constantly excelling in STEM may be the cause for womxn to decide to leave STEM, or even leave the workforce altogether.

R5: At least from a U.S. perspective, I see increasing awareness and acceptance of the diversity of womxn in the engineering workplace, particularly as this next generation of engineers steps into office and management positions. That said, while these changes often seem pervasive at the public level, they are often coupled and in conflict with corporate and government decision-making that affects gender equity in the nation more broadly, not just in engineering. Whether it is the Supreme Court questioning Roe v. Wade, the most powerful corporations' HR policies designed for heterosexual and cis-gender men, or large media sources presentation of news related to gender equity and womxn in power, these dynamics at a societal and cultural level remind me of the importance of not becoming complacent just because the people directly around me are "on my side" of gender issues or because I see small changes at a personal scale. Justice work makes us tired, but we cannot rest and must work until, and even after, we see change at the highest and most structural levels– the ones where systemic change happens. Other researchers said it first [8], but we need a paradigm shift in gender equity for engineers to one that accounts for diverse experiences of womxnhood and represents those experiences at the most powerful levels of our societies.

R3: There are a lot of terrible things happening at all levels of government/academia to make it harder for womxn and gender minorities to exist in the world. This may lead to less gender minorities wanting to go into a workforce that they have to fight for respect every day. On the other hand, gender diversity seems to be rising in engineering schools. Statistics supporting this may be misleading, as engineering can be seen as a leaky pipeline for gender minorities, as they often leave the field within the first five years in the work field [15].

R1: Despite there being several uphill battles that womxn in engineering are currently facing, and will continue to face in the near future to obtain a "seat at the table," it gives me hope that there are also several dialogues happening to ensure a right step forward in terms of gender equity. In institutions and workspaces in recent times, there have been multiple dialogues and in some cases ratification of contracts to ensure an expansion in the paid parental leave, and this step would definitely reduce barriers for early career womxn who are planning on starting a family. Also, there are a lot of free resources available for those who want to educate themselves and practice inclusivity in their workspace. Additionally, I think it is important to create initiatives (industry based fellowship/internship opportunities to pursue higher studies) that encourage more womxn to apply for and pursue engineering fields in which womxn are a minority. Initiatives that aid in future faculty development [26] and encourage womxn to learn about the process of applying for and thriving in a career in academia should be encouraged in academia. Also, there are several initiatives from national laboratories and institutions that engage K-12 students in robotics and coding, and have helped in breaking the barrier for young womxn joining those fields, and in future, a continued and increased effort in these initiatives in other fields of engineering would be helpful too.

6. ***What examples of structural change are important for realizing your goals for gender equity in the next 130 years?***

R4: Males dominate STEM fields at institutions of higher education [27], despite evidence that shows that girls have higher grades in STEM subjects than boys in school [28]. People assume boys will perform better at science and mathematics subjects just for being males. Findings from O'Dea et. al., [28] show that discriminatory actions toward females in STEM disciplines may discourage girls from pursuing STEM schooling and careers. Structural change must focus on shifting viewpoints of society toward women since gender is not an indicator of performance. Structural factors lead to structural change. Stephens et al., [29] defined structural factors as "environmental and material resources that can guide a student's behavior" (p. 6). Changing the resources and attitudes of individuals in the environment of students is essential for promoting structural change in STEM disciplines at schools and institutions of higher education.

The following paragraphs detail suggestions discussed by all of our panelists regarding necessary changes in the areas of K-12 education, undergraduate college, graduate school, and the workforce to promote gender equity.

K-12 education: Improving gender equality in engineering starts in elementary, middle, and high school as this is where people start to get interested in STEM and learn foundational science and math concepts. By the time these girls enter middle school, they already have lower STEM identities, self-efficacy, and career aspirations than their male classmates [30]. The panelists identified two areas of improvement for gender equity in K-12 education: access to STEM education and perceptions of womxn and other underrepresented identities in STEM. To improve access to STEM education, there need to be more pathways for students to explore STEM. This could include summer camps, coding workshops, and visits and job shadows at laboratory spaces in national laboratories and academic institutions. Not only will this introduce students to various STEM careers, but it will also give students STEM role models of various identities (including womxn and across socioeconomic backgrounds). By showing students how scientists and engineers are working on real world problems that affect them, they may be more invested in their science classes and careers. Furthermore, more funding needs to be available for engineering extracurriculars in low economic and rural school districts. To improve the perceptions of womxn and other underrepresented identities in STEM, the representation of scientists and engineers needs to be shifted in the classroom and in media. Textbooks, educational videos, and classroom examples need to depict people with different genders, races, and ethnographies, allowing young students to see themselves as engineers. Teachers need to be trained on how to avoid microaggressions and foster inclusivity in classrooms. Diversity, inclusion, and ethics need to be included in the K-12 STEM curriculum.

Undergraduate education: Following changes to K-12 education, undergraduate education needs to undergo systemic changes to ensure equitable access to STEM, increase knowledge of social issues, and create a comfortable learning environment for gender minorities. To ensure equitable access, community colleges and smaller public universities need to have the same access to resources as larger, more expensive schools. The stigma about going to these schools needs to be removed, and resources for easy transition into 4-year colleges need to be available for all transfer students. STEM career resources also need to be available for womxn, including internships, co-ops, and panel discussions featuring successful womxn in engineering. This will give students experiences to explore career options and will be beneficial when applying for jobs. Seeing successful womxn engineers, students will be comforted to know they can achieve success in

engineering and be prepared for the issues they will face in the field. By including social context for engineering design, the next generation of engineers will create socially conscious designs and fight for equity in their future careers. This inclusion of social context should be in the forms of case studies, debates, or role play, capstone projects rather than just historical examples, which will teach students how to critically think about such issues and consider ways in which larger social structures serve to empower or disenfranchise people. Furthermore, education should include inclusivity training to discuss issues of equality and inclusion, including gender equity in the field and how to respect diverse gender identities. Finally, steps need to be taken to ensure that the engineering classroom space is comfortable for all students. Professors should have formal training on how to incorporate inclusive teaching pedagogies into their classroom, which should include asking and respecting students' pronouns and preferred names, avoiding microaggressions, and creating clear behavioral expectations [31]. Social skills, including teamwork and communication, need to be explicitly taught and encouraged in engineering students. Specifically when working in teams, professors must ensure that managerial work (note taking, proofreading, organizing tasks, etc.) is shared amongst all team members and is not only expected of womxn. Teams should be created, especially in underclassman courses, with special care to not isolate womxn or other underrepresented populations, which can help retention issues and help avoid them being pushed into non-technical areas of the project or not taken seriously in groups [32]. The overall undergraduate college environment needs to undergo systemic change to ensure inclusion of gender minorities in STEM as well, including through better access to mental, gender-affirming, and reproductive healthcare.

Graduate education: Graduate programs must undergo structural change to promote the continuation of gender minorities into high achieving STEM roles, which includes prioritization of social issues in engineering graduate school research, creation of inclusive spaces, and better benefits for graduate students. Similar to the need of highlighting social issues in undergraduate classrooms, incorporating social justice issues into academic engineering research will create socially conscious engineers and highlight the importance of consideration of human factors in design. The cultures of engineering departments need to be more inclusive for womxn and other underrepresented identities. This can be achieved from better social support and discussions of the importance of identity and positionality in engineering. For example, prioritization of work-life balance for graduate students can be achieved through professors encouraging vacations/breaks, leading by example, and highlighting the importance of creating and maintaining work related boundaries. Resources and support should be provided for transitioning to graduate school, particularly for people with families and returning students. Workshops for fighting biases, imposter syndrome, and avoiding microaggressions should be required for students and faculty. Students should have access to tools to maintain their mental health and promote wellness. Benefits for graduate school should be increased to make it easier for womxn to persist in graduate school, including mental health care, gender affirming care, parental leave, living wages, access to affordable childcare, relocation funds, and emergency funds.

Workplace: Finally, structural changes to workplace benefits, expectations, and culture should be encouraged to ensure the success of gender minorities, not just to survive in engineering, but to thrive and achieve high level jobs. Benefits should be provided that promote equity and ensure access to resources, starting with dual-career hiring practices in engineering academia that are based on heterosexual and other limited definitions of partnership and marriage. In tandem,

parental leave should be available to any parent and the stigma around being a working parent should be relieved. Mothers should not be expected to be the sole caretakers of their children and be given the autonomy to decide their own career and personal priorities. Fathers should be able to take paternity leave without judgment. Same sex and gender non-conforming parents should have access to all the benefits of partnerships and marriage as well as resources for parents; their parenthood should never be questioned or judged. Gender-affirming healthcare should be available to all and appropriate leave should be given for procedures without question. Reproductive healthcare should be available to all, and employers should not be able to dictate or comment on their employees' use or access to such. Diversity, equity, inclusion, and justice (DEIJ) should be prioritized in the workplace, and training should be available and expected to be completed by employees. These trainings should expand upon basic DEIJ topics and delve deeper into social justice issues impacting employees. DEIJ initiatives should not only be expected of those with underrepresented identities, and those working on solving DEIJ issues should be appropriately compensated for their time. Perpetrators of microaggressions or unjust behaviors should be appropriately educated and punished in the workplace. Employers should be supportive of and help ensure smooth transitions for womxn returning to the workforce after periods of not working, including for child raising responsibilities, gap years, relocation, the pandemic, etc. Organizations should exist in the workplace to support underrepresented employees and give resources to ensure equity. Support systems and mentorship programs should be available for womxn in the workplace to ensure they are not alienated and have access to the resources, including mental and emotional support, to persist in engineering.

Discussion and Panel Summary

Efforts to achieve gender equity in engineering are gaining more importance on daily basis, and the perspectives of graduate students and postdoctoral students in engineering are critical for creating thorough and inclusive discussions about structural change and the improvement of gender equity in STEM and the ways in which gender equity intersects with other identity-based marginalization in the field.

This panel paper adds to literature on gender equity in engineering education by expanding on graduate and postdoctoral students' perspectives, and specifically those with diverse experiences of womxnhood in engineering. These narratives are overlooked in the current literature and provide more nuance to the ways in which engineering culture's domination by cis-gender, heterosexual, and white men impacts gender equity in the field, as well as the ways that engineering cultural norms collide with the diversity of religions, cultures, and experiences of womxnhood in the field today. In addition, panel discussions suggest the ways in which gender equity issues for womxn engineers are structural in nature (i.e., assumptions about engineers limit what it means to be a womxn in the field through policies and procedures with systemic effects), the importance of critical research approaches with intersectionality in mind in this space, and the how gender equity issues in engineering span contexts, not just the undergraduate and faculty experience.

In this panel paper, we make actionable recommendations for how to improve educational and workplace environments for womxn in engineering and STEM. We suggest better access to STEM education for all students at all educational levels. Media and educational resources should represent and highlight the achievements of underrepresented engineers so that students can see

themselves as engineers from an early age. Engineering needs to incorporate social issues into its research, industry, and education, including through case studies, training, and open discussions. This is necessary to promote socially conscious engineers and foster feelings of importance of all identities in engineering. Inclusivity needs to be prioritized in the classroom and working environment. To help ensure access to resources for the success of all gender identities, benefits for graduate students and employees should include parental leave and mental, reproductive, and gender-affirming healthcare. All engineers should reflect upon their biases towards gender in STEM and move towards a more equitable mindset. Through these structural changes, we believe that the engineering field of 130 years from now will be an inclusive place for all gender minorities to succeed.

Panel Recommendations

Following the collection of thoughts from the panelists, panelists were asked to review the paper, and to select one to two research questions they felt were the highest priority to investigate.

In summary, the graduate students and postdoctoral researchers on this panel proposed that future scholarship examine these questions:

- How do womxn of diverse religious/ethnic/cultural/racial backgrounds envision gender equity? In other words, what are the major impacts of intersectionality of marginalization towards achieving gender equity?
- How does gender identity impact how individuals act around peers in academia and the workplace?
- What are the structural changes in academia that could be enacted in short terms to ensure womxn are not leaving STEM?
- What social support structures do womxn build to help persist in STEM? How can institutions contribute to or encourage these support networks?
- How do trans- and non-binary people experience gender in STEM differently than their cis-gender peers?
- What help seeking behaviors do womxn in STEM exhibit? How can these be encouraged and supported?

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